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SPECIFICATION

HOT AIR HEATER

FIELD OF THE INVENTION

The present invention relates to hot air heaters, such as hair driers, desktop hot air heaters, etc.

BACKGROUND OF THE INVENTION

Hot air heaters having a heating element such as nichrome wire, wound around an insulating, fire-resistant substrate such as a mica plate, are generally known.

Also known are hot air heaters in which a carbon molding is additionally attached to the hot air nozzle to thereby add far-infrared ray effects produced by the carbon molding (e.g., Japanese Utility Model Registration Publication No. 3011964).

Electromagnetic waves are generally classified into radio waves, infrared rays, visible light, ultraviolet rays, X-rays and γ rays, in order from the longest wavelength to the shortest (i.e., from the lowest frequency to the highest), and the shorter the wavelength, the larger the photon energy. When visible light or ultraviolet rays strike a substance, such electromagnetic waves cause a chemical reaction and deteriorate the substance. Intense ultraviolet rays, X-rays and γ-rays adversely affect the living body. Electromagnetic waves with wavelengths longer than infrared rays generally do not cause chemical reactions, but at high intensities, they heat substances. It has not been clarified whether electromagnetic waves with longer wavelengths than infrared rays (radio waves) influence the human body, but studies have been made recently in many countries on the effects of some types of radio waves on the human body. Some countries, for example, Sweden, restrict electric fields to a maximum of 0.025 kV/m and magnetic fields to a maximum of 2.5 mG in the case of radio waves with wavelengths of 2 to 2000 Hz and at a distance of 50 cm from the human body (SWEDISH BOARD FOR

TECHNICAL ACCREDITATION GUIDELINE: MPR2). Conventional hair driers are said to generate a magnetic field of about 70 mG at a distance of 50 cm. Further, it has been reported that electromagnetic waves have caused malfunctions in electronic devices such as semiconductors, pacemakers, etc.

Hot air heaters having a carbon molding attached to the hot air nozzle are disadvantageous in that carbon moldings are expensive and increase the price of the heaters.

DISCLOSURE OF THE INVENTION

An object of the invention is to provide a hot air heater capable of reducing the emission of a certain type of electromagnetic wave.

Another object of the invention is to provide a hot air heater with enhanced infrared radiation efficiency at low cost.

To achieve the first object, the hot air heater of the invention comprises an insulating fire-resistant substrate and heating wires wound therearound, wherein a plurality of wires that are connected in parallel or series between an input line and an output line of an electric power supply line are wound around the insulating fire-resistant substrate in such a manner that the current runs in opposite directions through the heating wires so that the electromagnetic waves generated from the heating wires cancel each other out.

The hot air heater of the invention may be configured in such a manner that a first heating wire and a second heating wire are connected in parallel between the input line and the output line of the electric power supply line and are alternatively wound around the insulating fire-resistant substrate in the same direction and wherein the adjacent loops of first and second heating wires have the same or substantially similar winding diameters, in such a manner that the current runs in opposite directions through the first and second heating wires so that the electromagnetic waves generated from the heating wires cancel each other out.

To achieve the second object, the hot air heater of the

invention is characterized by comprising a ceramic honeycomb structure disposed downstream of the heating wire.

Preferably, the ceramic honeycomb structure has a coating containing carbon powder and the coated ceramic honeycomb structure has an emissivity of 0.8 or more over the entire infrared wavelength region.

More preferably, the coated ceramic honeycomb structure has an emissivity of 0.9 or more over the entire infrared wavelength region.

Preferably, the coating containing carbon powder is an impregnation coating.

Preferably, the ceramic honeycomb structure is disposed in the vicinity of the heating wire.

Preferably, the ceramic honeycomb structure is coated with a glassy carbon. The glassy carbon coating is preferably formed by impregnating a ceramic honeycomb structure with a glassy carbon precursor resin, followed by calcination under a non-oxidizing atmosphere.

According to the hot air heater of the invention, electromagnetic waves are weakened by causing the current to run in opposite directions through adjacent heating wires.

Further, the infrared radiation efficiency can be enhanced by disposing a ceramic honeycomb structure downstream of the heating wire.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cut-away view of a first embodiment of the hot air heater of the invention.

FIG. 2 is a conceptual diagram illustrating a method of winding the heating wires according to the first embodiment.

FIG. 3 is a conceptual diagram illustrating a method of winding the heating wires according to the second embodiment.

FIG. 4 is a partial broken isometric projection illustrating a method of winding the heating wire according to the third embodiment.

FIG. 5 is a schematic diagram illustrating a modification of the third embodiment.

FIG. 6 is a schematic diagram illustrating a method of winding the heating wire according to the forth embodiment.

DETAILED DESCRIPTION OF THE INVENTION

Embodiments of a hot air heater according to the invention are described below with reference to FIG.1 to FIG.6. The embodiments described below illustrate examples of hair driers. Like numerals represent like elements throughout the drawings.

A first embodiment of a hot air dryer according to the invention is described first. As shown in FIG. 1, the hot air dryer 1 comprises an insulating fire-resistant supporter 2 that is wound with heating wires 3. The heating wires 3 are wound to form a coil along the direction in which hot air flows from the hot air dryer 1 or in the opposite direction.

The insulating fire-resistant supporter 2 may be made of a mica plate, a ceramic plate, or the like. The insulating fire-resistant supporter 2 shown in FIG. 1 is made of a crisscrossed plate-like body. The heating wires 3 may be composed of a coiled nichrome wire or the like. In FIG. 1, the numeral 4 represents a fan motor, and the numeral 5 represents a fan.

The heating wires 3 comprise, as schematically shown in FIG. 2, two wires, a first heating wire 3a and a second heating wire 3b which are connected in parallel between an input line 6 and an output line 7 of a power supply line. Note that the heating wire is shown rather than in a coil shape but by a mere solid line for the sake of convenience.

The first heating wire 3a has its input line 6 side wound from the rear end of the insulating fire-resistant supporter 2 toward the front end thereof, and connected to the output line 7 at the front end of the insulating fire-resistant supporter.

In contrast, the second heating wire 3b is connected with the input line at the front end of the insulating fire-resistant supporter, wound from the front end toward the rear end, and

connected to the output line 7 at the rear end of the insulating fire-resistant supporter 2.

The first heating wire 3a and the second heating wire 3b are wound at a desired interval so that they are alternately arranged. Both the heating wires 3a, 3b are wound in the same direction. In addition, as shown in FIG.1, the adjacent first heating wire 3a and the second heating wire 3b are wound around the insulating fire-resistant supporter 2 with the same diameter.

Current flowing in the adjacent first heating wire 3a and the second heating wire 3b as described above is in opposite directions to each other. Note that the power supply of the hot air heater is generally an alternating-current power supply. In this case, the current flowing in adjacent heating wires has opposite phases, and the current flowing in a given period of time is in opposite directions.

When the current flowing in the adjacent first heating wire 3a is in the opposite direction to that of the second heating wire 3b, magnetic lines of force and electric lines of force are cancelled out. This phenomenon is caused by phase inversion of the electric and magnetic fields.

Next, the hot air heater according to the second embodiment of the invention is explained with reference to the schematic diagram shown in Fig. 3.

As in the first embodiment, the hot air heater of the second embodiment comprises a first heating wire 3a and a second electric heating wire 3b connected in parallel between an input line 6 and an output line 7.

According to the second embodiment, the first heating wire 3a and the second heating wire 3b are both wound around insulating fire-resistant substrates (not shown), the second heating wire 3b being wound within the windings of the first heating wire 3a. The first heating wire 3a and the second heating wire 3b are wound in opposite directions. The first heating wire 3a and the second heating wire 3b are wound parallel to each other along the hot air stream direction, forming a concentric

circle when viewed from the front.

The first heating wire 3a and the second heating wire 3b are each wound around an insulating fire-resistant substrate (not shown) at regular intervals, preferably, as close as possible to one another.

In the second embodiment, the first heating wire 3a and the second heating wire 3b may be connected to the input line 6 (or output line 7) either at the front-end or at the rear-end of the insulating fire-resistant substrates.

In the second embodiment having the above structure, as in the first embodiment, the directions of the current running through the first heating wire 3a and the second heating wire 3b are opposite each other, thus enabling reduction of the electromagnetic waves.

Although the second embodiment has been described as using two heating wires, one skilled in the art will understand that four or more even-numbered heating wires may be employed instead. The number of heating wires can also be three or more odd numbers, and in such a case, by applying resistance to designated heating wires and thereby limiting the amount of current, or by other means, the electromagnetic waves generated from the heating wires can be made to cancel each other out.

Fig. 4 is a partially broken perspective view illustrating a third embodiment. In the third embodiment, a single heating wire 3 is connected in series between an input line 6 and an output line 7. The heating wire 3 is wound into a concentric cylinder-like form. The heating wire 3 is wound around the inner insulating fire-resistant substrate 2a, folded back at the end, and then wound in the opposite direction around the outer insulating fire-resistant substrate 2b.

As schematically shown in Fig. 5, a heating wire 3 on the inner and outer sides may be cross-wound to provide parallel connections, using the insulating fire-resistant substrate 2b as an insulating layer. Therefore, the condition that "the current runs in opposite directions" herein does not necessarily mean

that all of the directional components of the current are opposed each other, but means only that some of them are opposite. For example, in Fig. 5, the directional components (3ax, 3ay) of the current in the inner heating wire 3a and the directional components (3bx, 3by) of the current in the outer heating wire 3b have opposite components 3ay and 3by, whereby a weakening of the electromagnetic waves is achievable.

Fig. 6 is a schematic diagram illustrating the fourth embodiment. In the fourth embodiment, a heating wire 3a wound in the first winding direction and a heating wire 3b wound in the second winding direction, which is opposite to the first winding direction, are positioned adjacently and supported by an insulating fire-resistant substrate 2. In the illustrated example, the heating wire 3a and the heating wire 3b are composed of one heating wire and connected in series between an input line 6 and an output line 7, and the winding direction of such a heating wire is reversed between the heating wire 3a and the heating wire 3b. Although not illustrated, the heating wires 3a and 3b may be connected in parallel.

Further, as shown in FIG. 1, the hot-air heater of the present invention may have a cylindrical ceramic honeycomb structure mounted in a casing 10. The ceramic honeycomb structure 9 is disposed downstream of hot air stream from the heating wires 3 and has a multiplicity of hexagonal apertures formed along the direction of the air stream.

The ceramic honeycomb structure 9 can be made of SiC, SiO_2, B_4C, AlN, Al_2O_3, MgO and like known ceramic materials; in light of the production costs, cordilite can be advantageously used.

It is generally known that heated materials emit radiant energy proportional to the fourth root of the absolute temperature. In such a case, the radiant energy varies according to surface state. The higher the emissivity, the greater the radiant energy will be. The radiant energy approaches a maximum the closer the emissivity of a heating element is to 1, because an ideal blackbody has an emissivity of 1.

The ceramic honeycomb structure 9, thus constructed with such an above material, usually has an infrared radiation emissivity of 0.8 to 0.98. This, however, may be reduced to 0.7 or lower depending of the wavelength of infrared radiation.

Carbon powder has a high emissivity over the entire wavelength range. Taking advantage of this property, a coating containing carbon powder can be applied to the ceramic honeycomb structure 9 to give an emissivity of preferably 0.8 or higher, and more preferably 0.9 or higher, over the entire infrared wavelength range.

Such a coating containing carbon powder can be prepared by mixing and dispersing carbon powder in a resin binder, applying the obtained mixture to the ceramic honeycomb structure 9 using a sprayer, brush, etc., or by impregnating the structure with the mixture as in a dipping method, etc., and by subsequently drying the structure with the applied mixture coated thereon. Usable carbon powders include noncrystalline substances such as glassy carbon in addition to crystalline substances such as black-lead. The coating can also be applied to only one side, e.g. the hot air outlet side, of the ceramic honeycomb structure 9.

Stated more specifically, the coating can be prepared by, for example, mixing with stirring 5 to 30 parts by weight of carbon powder and 100 parts by weight of a room temperature-setting inorganic/organic hybrid binder (e.g. a phosphate- and polyhydroxybenzene-based binder: EMULSION TECHNOLOGY CO., LTD.), applying the obtained mixture to the structure or dipping the structure in the mixture, and air drying.

The average particle diameter of the carbon powder is preferably approximately 1 to 50 μm, more preferably approximately 1 to 30 μm, and most preferably 1 to 5 μm. The smaller are the particles, the more homogeneously the coating can be applied to or impregnated on the ceramic surface.

Alternatively, the infrared radiant efficiency can be enhanced without using carbon powder in the coating. A glassy carbon coating can be formed by, for example, impregnating the

ceramic honeycomb structure with a glassy carbon precursor resin, followed by calcining under a non-oxidizing atmosphere at a predetermined temperature (approximately 800 °C to approximately 2000 °C) for a certain necessary period of time. A glassy carbon coating may have a thickness of 5 to 100 μm.

The glassy carbon coating, when carbonized, will have an enhanced infrared radiation efficiency, and should exhibit an average emissivity of 0.95 or higher over the entire infrared wavelength range. For example, such a glassy carbon coating has a radiant emittance of 1.227 kW/m^2 at $\varepsilon = 0.95$ at 120 °C at the hot air outlet of the hot air heater (1.292 kW/m^2 for a blackbody of $\varepsilon = 1$ over the entire infrared wavelength range beyond a wavelength of 0.7 μm).

Preferable examples of such a ceramic honeycomb structure 9 are those made of porous materials for better impregnation. Pore diameters are preferably approximately 1 to 50 μm. When the pore diameter of the porous material is smaller than 1 μm, carbon powder tend to be lumpy. When the pore diameter is greater than 50 μm, inhomogeneous coating tends to result.

The ceramic honeycomb structure 9 is positioned downstream of the heating wire 3. In view of an infrared radiant efficiency, it is preferably disposed in the vicinity of the heating wire 3, e.g. preferably about 0 to 2 cm from the heating wire 3. When the heating wire 3 is disposed to wind, for example, cylindrically, the ceramic honeycomb structure 9 can be disposed in the cylindrical space formed by the wound heating wire 3.

Measurements were made of the electromagnetic waves of a hot air dryer having the heating wire configuration shown in Fig. 6 (Example 1) and of a commercially available conventional hot air dryer wherein all the heating wires are coiled in the same direction and all electric current flows in the same direction (Comparative Example 1). The results are shown in Table 1.

The test conditions were as follows:

Heating wire: 0.3 mm ϕ, nichrome wire

Power consumption: 1200 W

Power supply: AC 100 V, 60 Hz

Measuring instrument:

Electric field: ME3 electromagnetic wave measuring instrument produced by Marburg Technic (Germany)

Magnetic field: EMS tester TES1390 produced by TES Electrical Electronic Corp.

Measurement positions: (A)-(C)

(A): about 5 cm in the blowing direction from the hot air outlet

(B) about 5 cm from the casing surface over the position of the heating wire

(C) about 5 cm from the casing surface over the position of the fan motor

[Table 1]

	Example 1	Comparative Example 1
Magnetic field (measurement position: A)	1.5 mG	22.0 mG
Electric field (measurement position: A)	30 V/m	90 V/m
Magnetic field (measurement position: B)	4.0 mG	30 mG
Electric field (measurement position: B)	80 V/m	100 V/m
Magnetic field (measurement position: C)	60.0 mG	60 mG
Electric field (measurement position: C)	100 V/m	110 V/m

The results in Table 1 show that in Example 1, the magnetic field and electric field decreased sharply at the measurement position (A).

Since, in a hair dryer or the like, the hot air outlet is closest to the human body, it is important that the electromagnetic waves at the measurement position (A) be small. Although the measurements in Table 1 were carried out without grounding, the electric field will be further decreased if

measurements are carried out with the hot air heater grounded.

Next, comparative experiments with ceramic honeycomb structures were conducted to compare those having a carbon powder coating with those having no carbon powder coating in terms of infrared emissivity.

Example A of a ceramic honeycomb structure

Graphite powder (1 g) (average particle diameter: 12 μm) was mixed into a resol-type type phenol resin methanol solution (10 g) (resin content: 50 wt%). A ceramic honeycomb structure (diameter: 3 cm) comprising cordierite was coated with this mixture by impregnation and dried. The resulting product had an infrared emissivity of 0.96.

Example B of a ceramic honeycomb structure

A solution of a resol-type phenol resin in methanol was adjusted to a resin solid content of 30 wt%, giving a glassy carbon precursor resin. A mullite honeycomb structure was impregnated with the glassy carbon precursor resin, dried, and then cured at 150°C. After this was calcined in nitrogen gas from room temperature to 1000°C over 12 hours, the temperature was lowered to room temperature over 8 hours, thereby coating the mullite honeycomb structure with glassy carbon. The resulting mullite honeycomb structure coated with glassy carbon had an infrared emissivity of 0.95.

Example C of a ceramic honeycomb structure

A solution of resorcin (1 mol), terephthalaldehyde (1.5 mol), and curing accelerator (p-toluenesulfonic acid) (0.01 mol) in ethanol was adjusted to a resin solid content of 30 wt%, giving a glassy carbon precursor resin. A mullite honeycomb structure was impregnated with the glassy carbon precursor resin, dried, and then left at room temperature for 5 hours to be cured. After this was calcined in nitrogen gas from room temperature to 1000°C over 12 hours, the temperature was lowered to room temperature over 8 hours, thereby coating the mullite honeycomb structure with glassy carbon. The resulting mullite honeycomb structure coated with glassy carbon had an infrared emissivity of

0.95.

In contrast, uncoated ceramic honeycomb structures as comparative examples of ceramic honeycomb structures had an infrared emissivity of 0.87 to 0.89.

The measurements of infrared emissivity were carried out using an IT-540N radiation thermometer (product of Horiba, Ltd.) in the following manner: (1) A black body spray was applied to part of the object to be measured, and the object was then heated. (2) The part to which the black body spray had been applied was subjected to measurement using an IT-540N radiation thermometer with the emissivity of the black body spray being the emissivity set value. (3) A part to which the black body spray had not been applied was subjected to measurement, adjusting the emissivity set value such that the measurement value was equal to the already measured temperature of the part to which the black body spray had been applied. (4) The emissivity obtained by adjustment was taken as the emissivity of the object.